PERFORMANCE OF THE LAMPF OPTICALLY PUMPED POLARIZED ION SOURCE

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ABSTRACT

In 1992, the LAMPF optically pumped polarized ion source (OPPIS) was used in experiments demanding a wide range of currents and polarizations. OPPIS was operated in different configurations to meet the differing current and polarization requirements for each experiment. We describe methods used to increase beam polarization at the expense of current for experiments that were count rate limited. OPPIS can be operated at 50 μA, giving 56% polarization, 25 μA with 65% polarization, or 2 μA with 77% polarization. The source reliability in 1992 was excellent, easily exceeding 95%. Contributions to experimental systematic errors made by the source were measured in 1992. We speculate about further improvements that can be made to OPPIS.

A more complete description of OPPIS can be found elsewhere.[1] There are many factors that affect its performance. Some of these, such as the design of the ECR source, ECR extraction optics, or thickness of the alkali vapor in the ionizer cell, primarily affect the beam intensity, I. Others, such as the magnetic field at the polarizer cell or design of the Sona region, affect the H^- beam polarization, P. There are many variables, however, that affect I and P simultaneously - usually in such a way that there is a tradeoff between the two. Understanding the variables and how to compromise between I and P has allowed us to meet the needs of different experimenters during the LAMPF 1992 run cycle.

One way of trading P for I is by varying the thickness of the polarized K vapor target. The H^- beam intensity increases linearly with K vapor thickness over a wide range of target thicknesses. However, the vapor thickness that can be pumped to maximum polarization is restricted by the limited laser power and radiation trapping. This relationship has been reported by many.[1,2,3,4]

Another factor that determines the relationship between I and P is the geometry of the extraction optics of the ECR source. The plasma lens has a hexagonal close-packed array of 1.0 mm diameter holes with 0.25 mm spacing between holes. The H^+ current extracted from the

ECR (like the final H⁻ beam) is proportional to the total extraction area and therefore the number of holes in the array; arrays of 7, 19, and 37 holes were used in 1992. The array size determines the diameter of the H^+ beam in the K cell. The K is more highly polarized along the axis of the polarizer cell because of depolarizing wall collisions at the walls and a higher laser intensity on the axis. Thus, the polarization is higher when more H^0 beam is formed near the axis of the cell.

The range of I and P is also affected by aperturing the beam in the 750 kV transport line. This result indicates a spatial dependence in the beam polarization. With a smaller aperture, current is lost, but the polarization is increased.

Figure 1 demonstrates how different source operating parameters can produce different values of I and P. Data taken with three different H^+ beam diameters show how P is increased at the cost of I. For each extraction geometry, the thickness of the K in the polarizer cell can be varied to give a range of source performance. The figure also shows how the polarization can be increased by inserting a small aperture at 750 kV.

In 1992, we examined contributions that OPPIS might make to systematic errors in precise experiments.[5] These measurements, descibed in the next two paragraphs, were made while the source was in normal operation with the 19-hole ECR extraction array and with no aperture in the 750 kV beam line.

Systematic errors will result if the position, polarization, or current of the beam fluctuates in a way correlated to its spin state. We

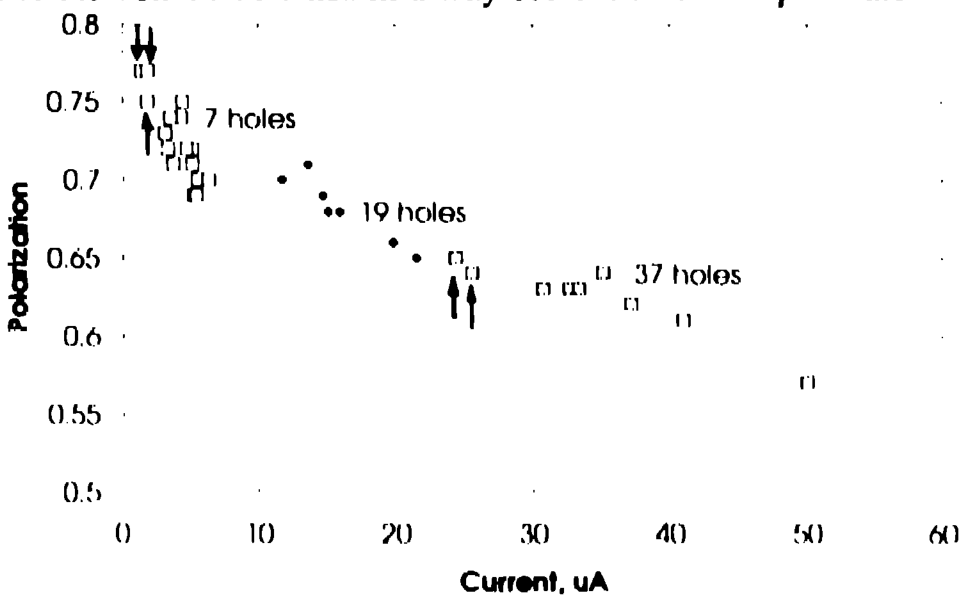

Fig. 1 The I and P of OPPIS can be varied by using ECR extraction arrays with different numbers of holes, as shown by the different symbols. The different data points in each series are from placing an aperture in the 750 kV beam line (denoted with arrows) or from changing the thickness of the K vapor.

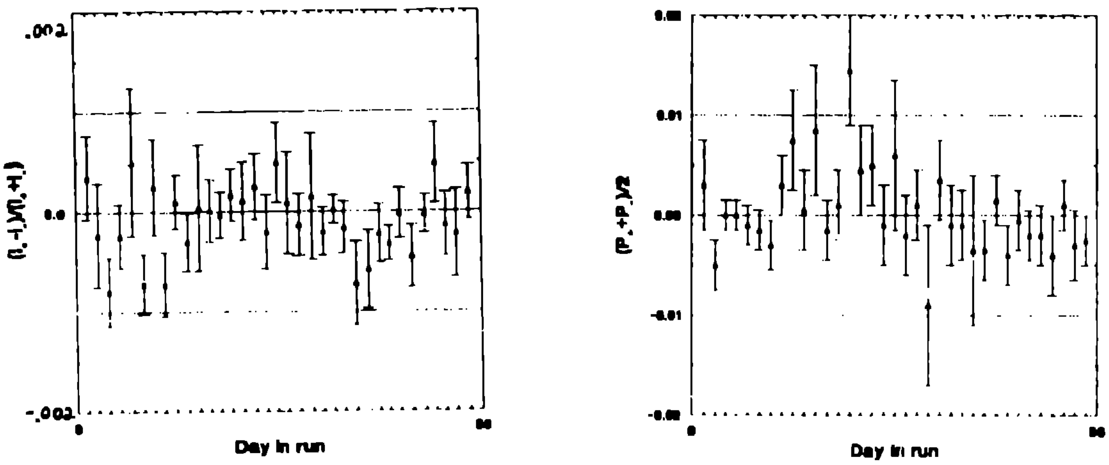

Fig. 2 (a) Intensity asymmetry i and (b) polarization asymmetry p vs. time. The time interval was from June 15 to July 25, 1992, during normal OPPIS beam production. In some cases, data from several days have been combined, when the beam was off for a long time.

measured the motion of the 5 mm diameter beam to be 0 +/- 0.01 mm. The asymmetry in the intensity, $i = (I_+ - I_-)/(I_+ - I_-)$, averaged (-12 +/- 5) x 10^{-5} over a month long period. The asymmetry in the polarization, $p = (P_+ - P_-)/2$, averaged (-5 +/- 5) x 10^{-4}. Figure 2 shows i and p measured daily over a month.

There are other characteristics of the source that an experimenter may need to know in order to avoid systematic errors. Depending upon the linac tune, the center of the full energy 800 MeV beam had relative polarizations of up to 3% higher than the outer edge. The beam pulses are produced at 120 Hz, each about 850 μs long. Under some conditions, the relative polarization at the beginning of the pulse was up to 2% higher than at the end.

Table I outlines the performance of OPPIS since 1989. There are still some modifications that should be explored to improve the performance of OPPIS. Measurements made at TRIUMF[6] confirm calculations[7] showing that higher polarizations are obtained if the magnetic field at the polarizer cell is increased. Well over 10% relative improvement in polarization with no loss in current can be expected if a magnet of higher field is installed. Studies show that the H^+ beam intensity from the ECR is still limited by the amount of available rf power. The overall source performance is limited by the laser power available, and data indicate that the K vapor is less polarized near the walls than in the center of the target. Therefore, more laser power would improve the current and polarization of the source.

In conclusion, OPPIS has proven to be a source of remarkable versatility. The range of its current and polarization can be balanced to accommodate a wide range of demands from experiments. OPPIS reliability was well over 95% in 1992. The optically pumped source is well suited for high precision experiments, such as charge symmetry breaking or parity violation. There are many avenues that promise even better performance for OPPIS.

Table I. A history of the current and polarization produced by OPPIS since its inception.

	Current	Polarization	P^2I
Lamb-Shift Source	0.8 μA	75%	0.45 μA
1989 OPPIS	4.0 μA	45%	0.81 μA
1990 OPPIS	25 μA	55%	7.6 μA
	15 μA	62%	5.8 μA
1991 OPPIS	38 μA	60%	14 μA
	20 μA	64%	8.2 μA
1992 OPPIS	50 μA	56%	16 μA
	25 μA	65%	11 μA
	2 μA	77%	1.2 μA

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